

Demodulation of AM Waves:

$$S(t) = A_c [1 + K_a m(t)] \cos(2\pi F_c t)$$

\downarrow
AM wave
 \downarrow
baseband signal
message

① Squer-Law Detector:

$$V_2(t) = a_1 V_1(t) + a_2 V_1^2(t)$$

$$V_2(t) = a_1 A_c [1 + K_a m(t)] \cos(2\pi F_c t)$$

$$+ a_2 A_c^2 [1 + 2K_a m(t) + K_a^2 m^2(t)] \cos^2(2\pi F_c t)$$

$$\frac{1}{2} [1 + \cos(4\pi F_c t)]$$

low-pass
Filter
2W

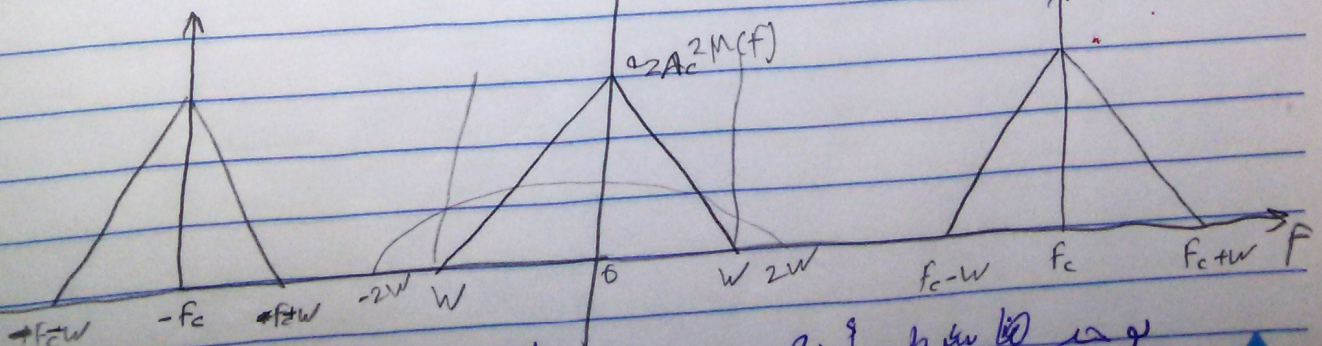
$$V_2(t) = a_1 A_c [1 + K_a m(t)] \cos(2\pi F_c t) + \frac{1}{2} a_2 A_c^2 + \frac{1}{2} a_2 A_c^2 K_a m(t)$$

$$+ \frac{1}{2} a_2 A_c^2 K_a^2 m^2(t) + \frac{1}{2} a_2 A_c^2 [1 + 2K_a m(t) + K_a^2 m^2(t)] \cos(4\pi F_c t)$$

Low-pass
Filter

Filter

$$|V_2(f)|$$

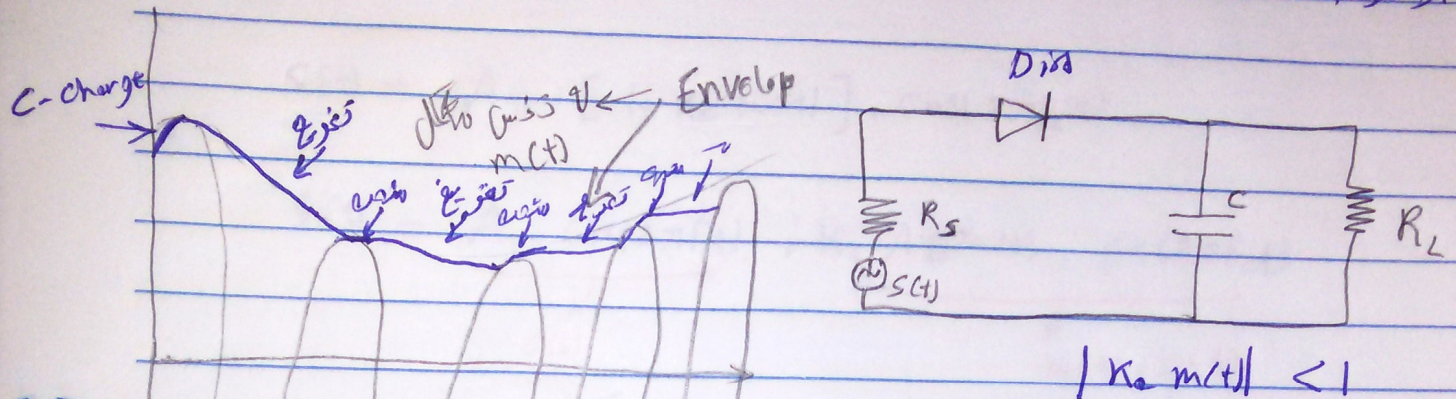


$$|K_a m(t)| < 1$$

$$m^2(t)$$

② Envelope Detector :

المشغل الحثي



$S(t) \rightarrow$ high value

Diode ON

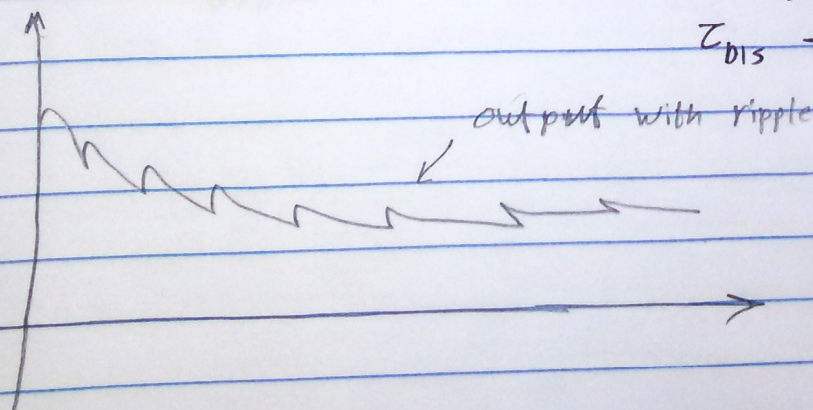
$C \rightarrow$ charging

$$\text{Charging time} = R_s C < \frac{1}{f_c}$$

$Z_c \rightarrow$ very small

$$\text{Dis charging time} = R_L C < \frac{1}{\omega}$$

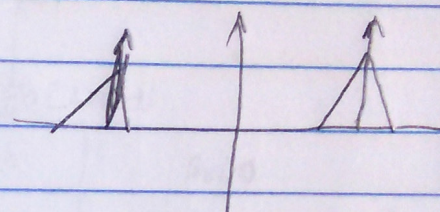
$Z_{DIS} \rightarrow$ كبير



$$S(t) = A_c [1 + k_e m(t)] \cos(2\pi f_c t)$$

$$S(t) = \underbrace{A_c \cos(2\pi f_c t)}_{\substack{c(t) \\ \text{Carrier}}} + \underbrace{k_e A_c m(t)}_{m(t) \cdot c(t)} \cos(2\pi f_c t)$$

no carrier, only side
band

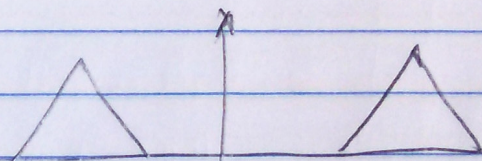


Double-Side band - with Suppressed Carrier

low, 1/2 as Carrier

1/2, 1/2 as

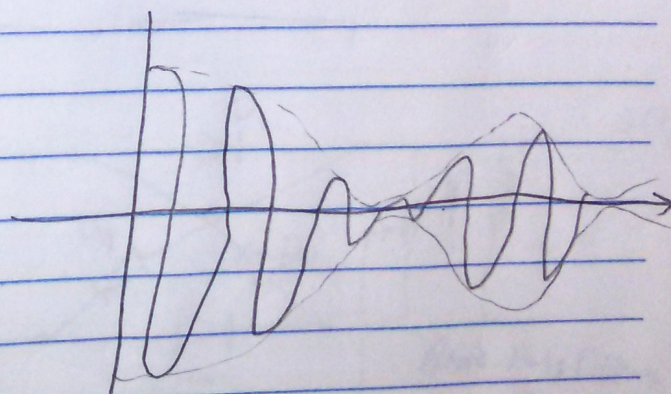
$$S(t) = c(t) \cdot m(t)$$



$$S(t) = A_c m(t) \cos(2\pi f_c t)$$

DSB-SC

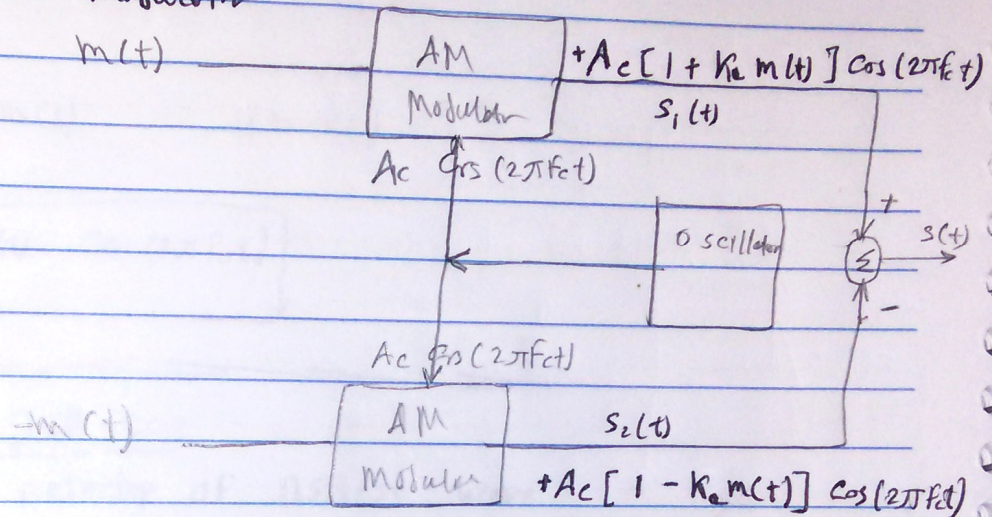
DSB-SC In Frequency Domain



DSB-SC in time Domain

① Modulator For DSB-SC :

1] balanced modulator



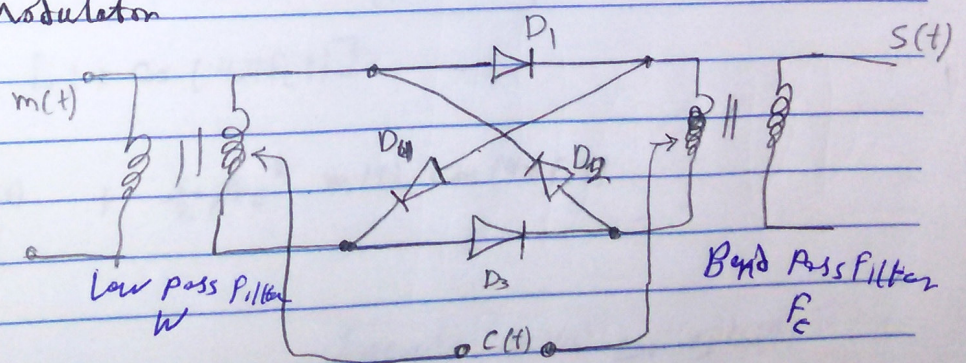
$$S_1(t) = A_c [1 + K_m m(t)] \cos(2\pi f_c t)$$

$$S_2(t) = A_c [1 - K_m m(t)] \cos(2\pi f_c t)$$

$$S(t) = S_1(t) - S_2(t)$$

$$S(t) = 2 A_c K_m m(t) \cos(2\pi f_c t)$$

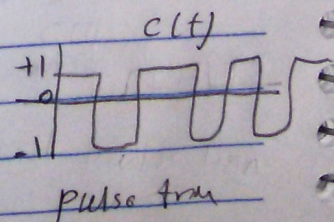
② Ring Modulator



$c(t) \rightarrow$ positive

$\rightarrow D_1, D_3$ ON
 $\rightarrow D_2, D_4$ OFF

$c(t) \rightarrow$ Negative
 $\rightarrow D_2, D_4$ ON
 $\rightarrow D_1, D_3$ OFF



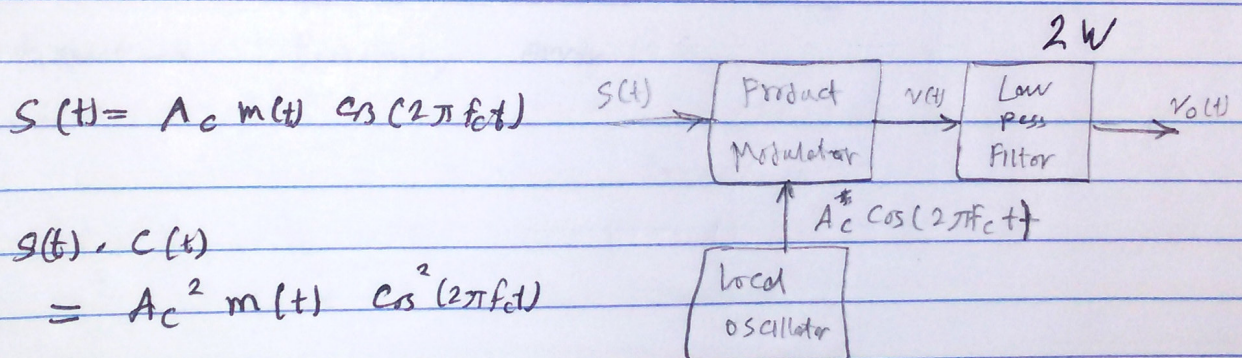
$$C(t) = \frac{4}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{2^{n-1}} \cos [2\pi f_c t + (2n-1)\pi]$$

$$S(t) = C(t) \cdot m(t) \quad (n=1)$$

$$S(t) = \frac{4}{\pi} m(t) \cos (2\pi f_c t)$$

* Detection of DSB-SC:

① Coherent detector of DSB-SC wave



$$S(t) \cdot C(t) = A_c^2 m(t) \cos^2(2\pi f_c t)$$

$$= \frac{1}{2} A_c^2 m(t) [1 + \cos(4\pi f_c t)]$$

$$V(t) = \underbrace{\frac{1}{2} A_c^2 m(t)}_{V_o(t)} + \frac{1}{2} A_c^2 m(t) \cos(4\pi f_c t)$$

Local oscillator can be written as

$$A_c' \cos(2\pi f_c t + \phi) \quad \text{if } \phi = 0$$

$$A_c' \cos(2\pi (f_c + \Delta f) t) \quad \text{if } \phi \neq 0$$

f_c $f_c + \Delta f$

Detection is done using a lock

phase error

$$c(t) = A_c' \cos(2\pi f_c t + \phi)$$

$$r(t) = A_c A_c' \cos(2\pi f_c t) \cos(2\pi f_c t + \phi) \cdot m(t)$$

$$= \frac{1}{2} A_c A_c' m(t) [\cos(4\pi f_c t + \phi) + \cos \phi]$$

$$V_o(t) = \frac{1}{2} A_c A_c' m(t) \cos \phi$$

$\phi = 0 \rightarrow \text{out} \checkmark$

$-90 \rightarrow \text{out } 0 \times$

Report \rightarrow frequency error